Disclosure of Invention
High Energy Pulse (HEP) Welding

First Described To: Rob McDaniel and Ben Garrison on 28 August 2003

Purpose of Invention:
This invention welds metallic materials by mechanical impulse, without need for thermal energy input.

Advantage over Conventional Processes:
The non-thermal approach averts strength and corrosion susceptibility in conventional weld joints. It also affords greater portability for spot welding.

Description:
See Figure A. A shaped projectile or high-velocity mass impacts the work piece with energy sufficient to generate fusion at the interface (faying surface). The projectile shape, at its perimeter, generates longitudinal acoustic waves incident on the work piece at an angle which mode converts into shear waves.

Longitudinal acoustic waves generated by the central part of the projectile are transmitted through the work piece and reflected from a shaped acoustic mirror (anvil). The mirror reflects longitudinal waves at a direction to mode convert into shear waves within the work piece.

The induced shear wave energy density is sufficient to exceed metallic crystal shear strength. The work piece transitions to a fluid state at the interface; disrupting surface metallic oxides to afford metallic fusion of surfaces in contact. This is analogous to thermal fusion welding, where the energy density is sufficient to convert material from a solid state to a liquid state.

Unique Features of Invention Diagramed in Figure A:
1. Air pressure is increased until rupture of the diaphragm cap of the integral projectile/diaphragm cartridge. This propels the projectile with controlled energy equivalent to the stored potential energy of the compressed gas.
2. The shaped projectile leading edge impacts and deforms the metallic work piece. Impulse generated compression or longitudinal waves are transmitted into the work piece. The angled part of the projectile leading edge induces mode conversion of longitudinal waves into shear waves.
3. Longitudinal waves transmitted through work piece are reflected by the shaped anvil mirror, back along a direction which mode converts to shear waves in the work piece.
4. Superposition of directly input and reflected wave energy converts solid state metal to fluid, fusing the work piece at the a bond zone.
5. Clamp-up force is afforded by pressurized hydraulic fluid behind the rubber bladder.

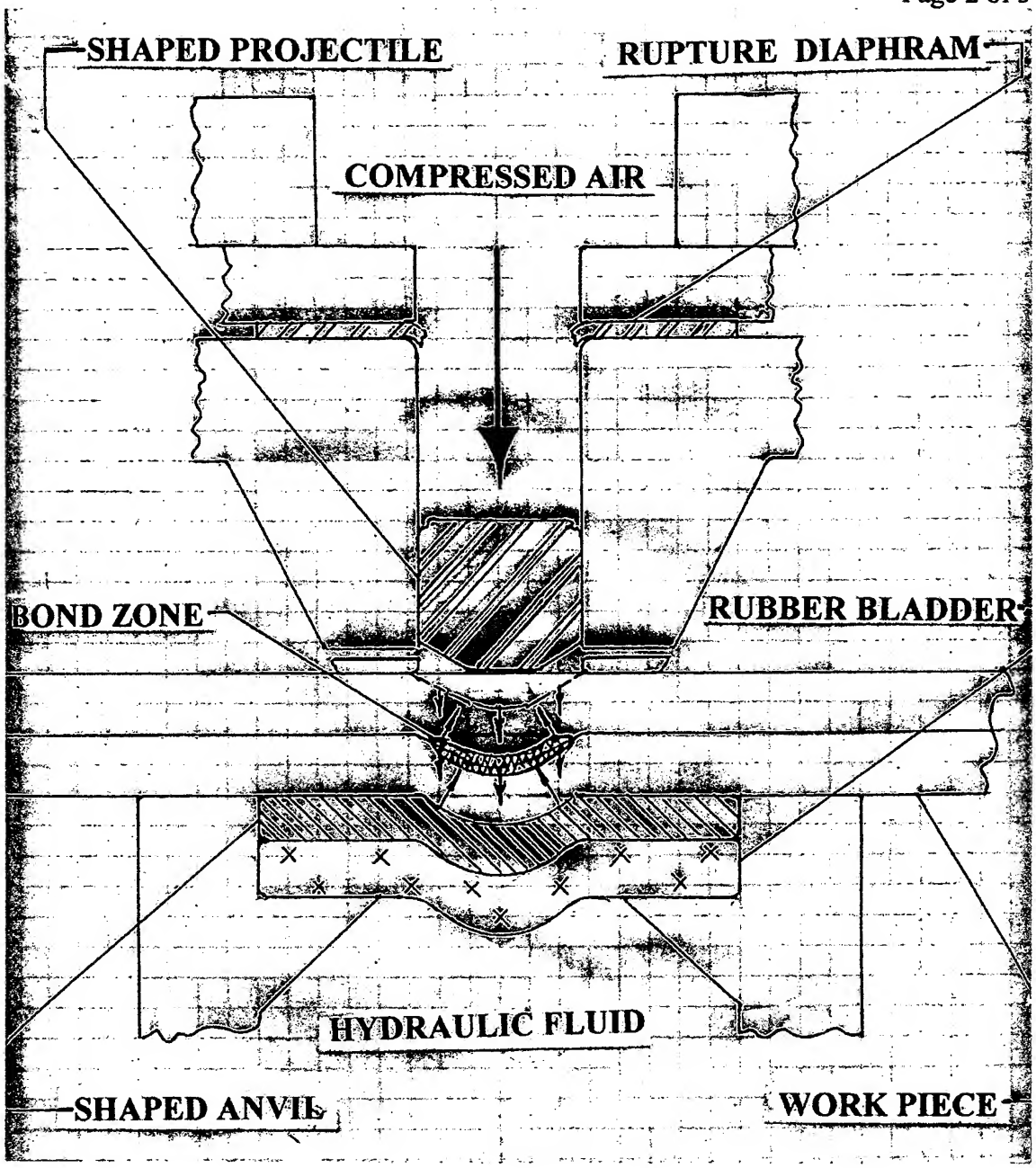

Figure A, Elements of the High-Energy Pulse (HEP) Welding Apparatus. Shear wave induced fusion is generated by a shaped projectile and shaped reflector.

Critical Design Elements:

- Projectile/diaphragm material, shape and dimensions.
- Anvil (reflector) material, shape and dimensions.
- Projectile kinetic energy.
- Acoustic impedance of the projectile, work piece, reflector, and reflector backing.

Application of Invention:
This invention, among other broad applications, is envisioned as a portable spot welder with an impulse welding gun, a motor driven high-pressure hydraulic pump, and a hydraulic accumulator with air feed to the compressed air chamber of the gun. Operation consists of:

1. Load the projectile/diaphragm cartridge into the welding gun,
2. Conduct hydraulic clamp-up of gun-to-work piece, and
3. Trigger valve compressed air into the gun chamber.

The diaphragm ruptures and compressed air propels the projectile onto the work piece. Incident energy superposed on reflected energy generates a spot weld.

Prior Art or Basis for Approach:

- The physics of acoustic waves and mode conversion in layered media is presented by Kinsler & Frey, "Fundamental of Acoustics", Second Edition, John Wiley and Sons, and Ewing, Jardetsky, & Press, "Elastic Waves in Layered Media".
- Impulse generated metallic bonding has been researched by the inventor at the Lockheed Georgia Materials Research Laboratory in the late 1960's.
- The inventor was a staff researcher at the Ohio State University Department of Welding Engineering in the mid-1960's. In that capacity, he conducted studies of High-Energy Ultrasonics in the deformation and bonding of metallics.

Read and Understood by:

Tom E Adams _____ **Date** October 1, 2003

L. Douglas Allen _____ **Date** October 2, 2003